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# Computer-Assisted Design and Engineering of Plate-Fin-Type Heat Exchangers - Part: Evaporator

G. Clocker

*VEB Kombinat ILKA Luft - und Kältetechnik*

B. Haussmann

*VEB Kombinat ILKA Luft - und Kältetechnik*

S. Heinritz

*VEB Kombinat ILKA Luft - und Kältetechnik*

S. Nowotny

*VEB Kombinat ILKA Luft - und Kältetechnik*

K. Thiele

*VEB Kombinat ILKA Luft - und Kältetechnik*

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G. GLÖCKNER, B. HAUSSMANN, S. HEINRITZ, S. NOWOTNY, K. THIELE  
VEB Kombinat ILKA Luft- und Kältetechnik, SFT, DRESDEN  
(German Democratic Republic)

## 1. ABSTRACT

Plate-fin-type heat exchangers are of extraordinary interest to refrigeration especially as concerns small- and medium-sized heat exchangers. In order to organize a flexible and custom-made manufacture we have developed a computer-assisted design- and engineering method the general principle of which will be explained as follows.

Plate-fin-type heat exchangers show a fixed structure. With respect to the manufacturing technique of the plate fins we will find a reduced number of cutting tool geometries (cutting tool data), which make it possible to develop an effective design strategy. The system now available makes it possible to determine the geometry and dimensions of components, segments and groups of the heat exchanger.

The software package which has been developed comprises

- thermodynamic calculation and design by means of a simulation model,
- computerized description of the geometry of component parts and of the catalogue of components,
- output of the component part list (catalogue) and the plotting of technical drawings,

and it forms simultaneously the data base which can be used to solve the computer-assisted planning (CAP) and computer-assisted manufacturing of this category of heat exchangers. All data needed to identify a particular heat exchanger are stored by means of a data bank. For the time being the whole system available takes into consideration solely evaporators. However, it can generally be applied to all kinds of plate-fin-type heat exchangers.

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## UNE METHODE DE CONCEPTION ASSISTEE PAR ORDINATEUR POUR ECHANGEURS THERMIQUES LAMELLAIRES, MONTREE A L'EXEMPLE D'EVAPORATEURS

RESUME: Des échangeurs thermiques lamellaires utilisés dans la technique du froid jouent un rôle extraordinaire dans la gamme des petites et moyennes puissances. Afin d'organiser une production flexible et satisfaisant aux besoins de la clientèle, on a mis au point une méthode de conception assistée par ordinateurs dont les principes fondamentaux sont présentés ci-après:

Pour l'échangeur thermique lamellaire la configuration extérieure et la composition de principe sont fixes. En outre il résulte de la technologie de fabrication des lamelles un nombre réduit de géométries de coup qui permettent la mise au point d'une stratégie de conception efficace. Le système actuellement disponible permet la fixation dimensionnelle de pièces isolées et de sous-ensembles.

Toutes les données nécessaires à l'identification d'un produit concret sont mémorisées par système de banc de données. Dans un premier temps, la solution de système tient seulement compte des évaporateurs.



## 2.1 PHYSICAL-TECHNICAL AND MATHEMATICAL BASIS OF THE EVAPORATOR CALCULATION

When carrying out the calculation the appropriate areas of superheat, evaporation and warming up are considered separately. The calculation is carried out in a direction which is opposite to that of the flow of the refrigerant, i.e. the calculation starts with the condition of the refrigerant leaving the evaporator which is to be found in the wet vapour or superheat region. In order to determine the surface coefficient of heat transfer and the pressure loss during evaporation the method developed by CHAWLA /1/ has been applied; for estimating the surface coefficient of heat transfer on the air side taking into consideration the condensation of moisture (frost formation) we have used the procedure proposed by WUNDERLICH /2/, and for the dry surface the method developed by SCHMIDT /3/. The pipe length available for the warming up and evaporation of the refrigerant is divided into a number  $N$  of segments each of which are determined fully thermodynamically. When the lower liquid line falls short the segments still available are determined by means of the surface coefficient of heat transfer valid for liquid flow. The calculation is carried out in an iterative manner in order to coincide with the given conditions of the refrigerant entering the evaporator. See Fig. 1.

The theoretical and partly empirical equations which have been applied guarantee an accuracy of the calculated refrigerating capacity in the order of  $\pm 20$  per cent when taking into account standard conditions. When more reliable experimental data are used which are valid for an appropriate evaporator or a certain plate fin geometry resp. an even greater accuracy can be achieved by introducing certain correction factors which are used to adapt the general equation.

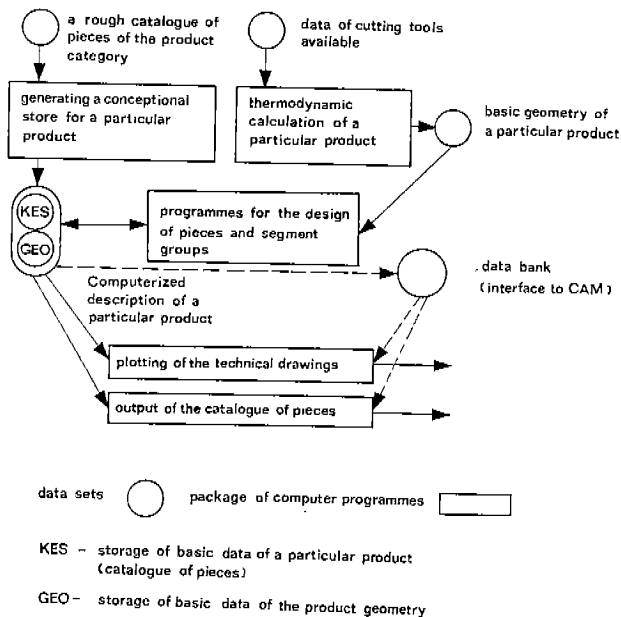


Fig. 2 - Schematic view of the programme package "design of plate-fin-type heat exchangers"

### 3. ELABORATION OF THE CATALOGUE OF COMPONENTS

The general composition of the programme package is shown schematically in Fig. 2.

By means of a questionnaire the general shape of the heat exchanger is generated and through it the first draft of the catalogue of components is selected from a data base of components. By means of the draft catalogue of components (pieces) a conventional store of the heat exchanger will be generated which includes the complete hierarchically structured design of a heat exchanger with the restriction that each component is described by means of a term and a preliminary class number. Fig. 3 shows the subdivision of the heat exchanger into groups, segments and components (pieces).

After finishing the process of generation the appropriate position of the catalogue, i.e.

- position number of the technical drawing
- position number of the appropriate material (or bar code)
- weight
- quality and dimensions of the material

are fixed by means of a computerized method, i.e. by means of special design programmes which exist for all groups of segments and components which must be manufactured whereby simultaneously all information necessary to describe the geometry of the pieces is fixed and stored within the data base. The computerized description now available comprises all data to identify and to prepare technical drawings of all groups, segments and components. The data of all other catalogue positions (commercially available and standardized parts, commodities) are taken from a data base of materials which are identified by means of particular position numbers.

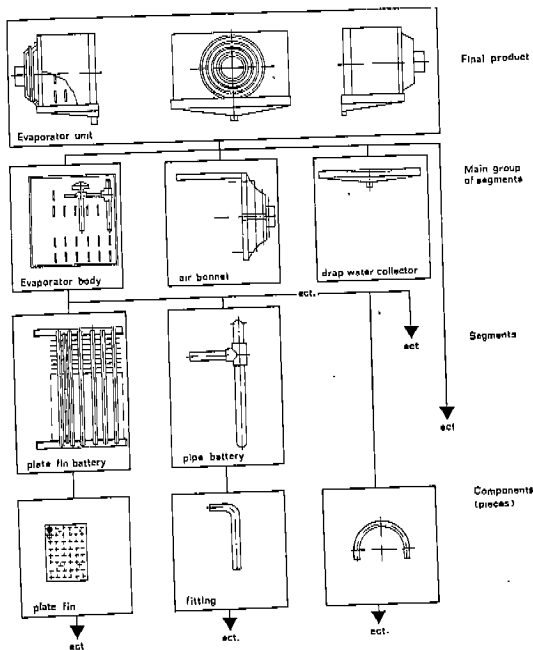


Fig. 3 - Schematic view of the decomposition of the evaporator into main groups, segments and pieces



The programme package "generation of technical drawings" makes it possible to

- arrange the different views
- represent the geometry of the different views
- carry out dimensioning according to international standards
- represent cross sectional views
- represent particular details
- designate views
- give out fitting dimensions and allowances
- carry out the caption and the legend.

## 5. CONCLUSIONS

The programme package described above carries out the design, calculation and dimensioning as well as the complete documentation (technical drawings and catalogue of pieces) necessary to manufacture plate-fin-type evaporators. The solution described involves CAD and CAP, and can be considered as a precondition for the CAM-phase which normally follows.

## REFERENCES

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3. Th.E. SCHMIDT: Der Wärmeübergang an Rippenrohren und die Berechnung von Rohrbündel-Wärmeaustauschern. Kältetechnik 15(1963)4, S. 98-102 und 15(1963)12, S. 370-371.